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BIOLOGICAL SURVEY OF MILFORD RESERVOIR, KANSAS, AUGUST 1969

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The report describes biological studies of Milford Reservoir and the Republican River made on August 10-11, 1969. This report indicates that water quality upstream and downstream from the impoundment was excellent and the Milford Reservoir does not have a detrimental effect on the biota of the Republican River.

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BIOLOGICAL SURVEY OF

MILFORD RESERVOIR, KANSAS, AUGUST 1969

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Environmental Protection Agency
Water Quality Office
Office of Enforcement and Standards Compliance
Division of Field Investigations, Cincinnati

1971

SUMMARY

1. Biological studies of Milford Reservoir and the Republican River on August 10-11, 1969, indicated that water quality upstream and downstream from the impoundment was excellent and that Milford Reservoir does not have a detrimental effect on the biota of the Republican River.
2. In the main portion and downstream from the reservoir, algal populations were small. To date Milford Reservoir is the most productive reservoir studied by Federal Water Quality Administration biologists in the Missouri Basin. However, algal nuisances are not expected to occur at the present level of algal production. The algae support a moderately sized benthic population which should support an abundant fish population.
3. Sufficient inorganic nitrogen and soluble phosphorus was present in the reservoir to maintain a high level of algal productivity. Neither of these nutrients appeared to be limiting.
4. The bottom animals, both upstream and downstream from the reservoir, are those associated with unpolluted environments. In 1969 the improved bottom animal community indicated that the downstream degradation noted during the initial years of impoundment no longer exists (Thomas, 1969).

BIOLOGICAL SURVEY OF

MILFORD RESERVOIR, KANSAS, 1969

As requested by the Army Corps of Engineers, through the Regional Director, Missouri Basin Region, Federal Water Quality Administration, an investigation of Milford Reservoir, Kansas, and reaches of the Republican River immediately upstream and downstream from the reservoir was conducted on August 10 and 11, 1969, to determine water quality and the condition of the biotic community as they might be affected by placing an impoundment on the river. Biologists from the Federal Water Quality Administration's Division of Field Investigations, Cincinnati, sampled the phytoplankton and bottom animal communities and algal nutrients, and determined primary production and light penetration. Personnel from the State of Kansas, Department of Health, sampled the reservoir and the Republican River to determine physical and chemical water quality characteristics. Some of the chemical data used in this report will be presented with the other data collected by the Kansas Department of Health in a comprehensive report compiled by the Army Corps of Engineers.

Algal nutrient samples (NO_3-N, NH_3-N, Organic N, Soluble P, and Total P) were analyzed according to the FWQA Methods for Chemical Analysis of Water and Waste (1969). Phytoplankton and bottom

animal samples were collected and enumerated according to the methods prescribed in the Standard Methods for the Evaluation of Water and Wastewater, Twelfth Edition. Plankton productivity was determined by dissolved oxygen differences with the light and dark bottle technique prescribed in the Standard Methods for the Evaluation of Water and Wastewater, Thirteenth Edition.

RESERVOIR DESCRIPTION

Milford Reservoir, located in the northeastern section of Kansas near Junction City (Figure 1), was completed and filled in 1967. This reservoir has a gross storage capacity of 1,160,000 acre feet. Of this capacity, 460,000 acre feet are for multi-purpose use and 700,000 acre feet are for exclusive flood control storage. At normal water level, the reservoir has a surface area of 16,000 acres and a shoreline of 163 miles. The major use of the reservoir is flood control; however, many access areas have been provided for recreational use of the reservoir.

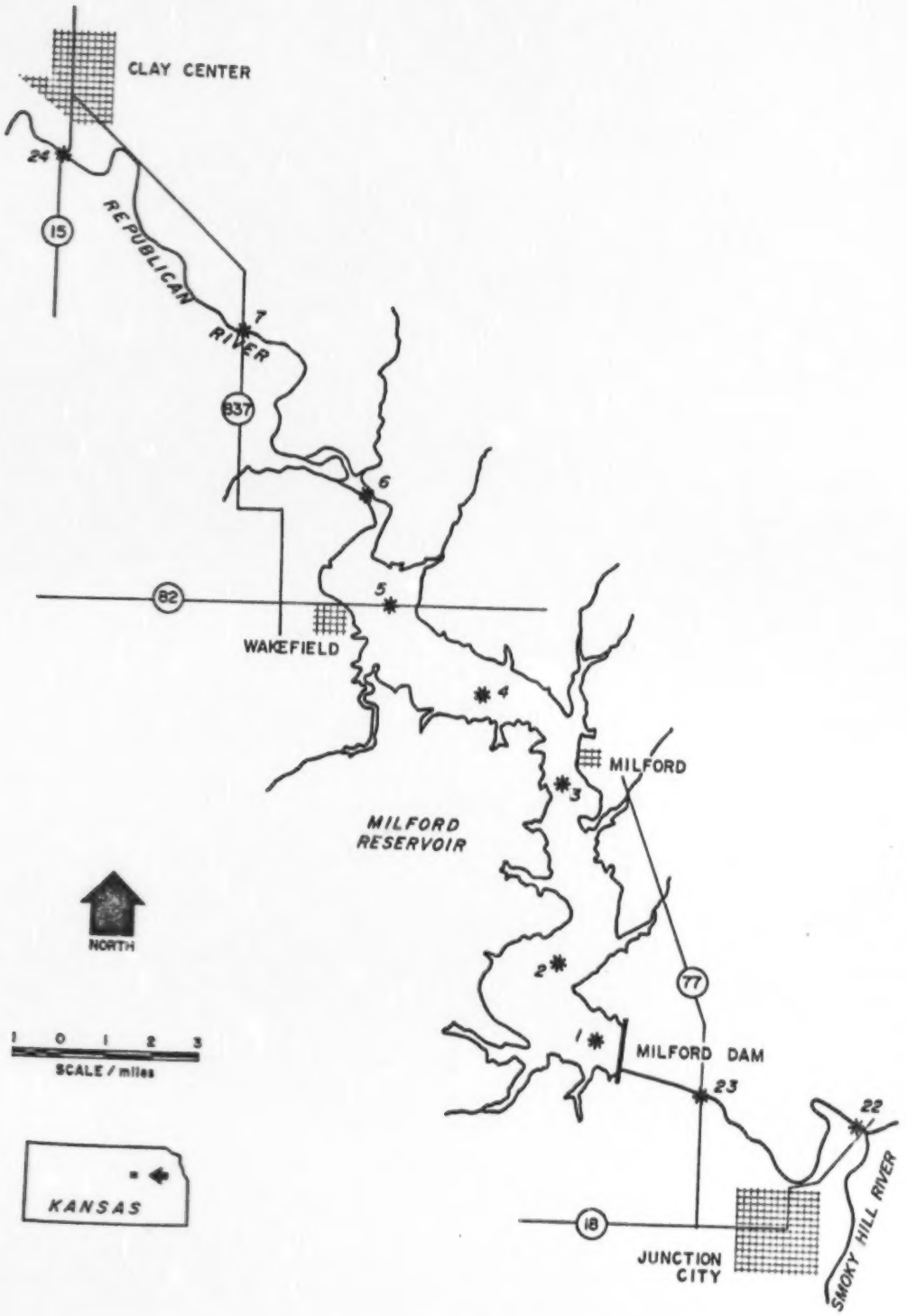

FIGURE I. SAMPLING STATIONS, MILFORD RESERVOIR AND REPUBLICAN RIVER, KANSAS, 1969

PHYSICAL AND CHEMICAL WATER QUALITY

In August 1969 Milford Reservoir did not have a definable thermocline; however, thermal stratification was sufficient to impede mixing and to allow dissolved oxygen withdrawal from the bottom waters (Figure 2). In the deepest part of the reservoir the temperature was 25.0° C which was only one degree cooler than the surface temperature. The dissolved oxygen in the bottom waters at stations 2, 3, 5 and 6 was less than 4.0 mg/l. Surface waters at the headend of the reservoir and in the Republican River upstream and downstream from the reservoir were super-saturated with dissolved oxygen. Upstream this super-saturation resulted from the dense algal populations (Figure 3).

In August 1969 the concentration of total suspended solids was eight percent less than in August 1968 (Thomas, 1969; State of Kansas Data, 1969) resulting in a two foot increase in the depth of the euphotic zone. The greater depth of the euphotic zone permitted greater phytoplankton productivity in Milford Reservoir.

The two major algal growth nutrients, inorganic nitrogen and phosphorus, are in sufficient supply to promote an abundant algal population (station 1 - greater than 2500 per ml). In the

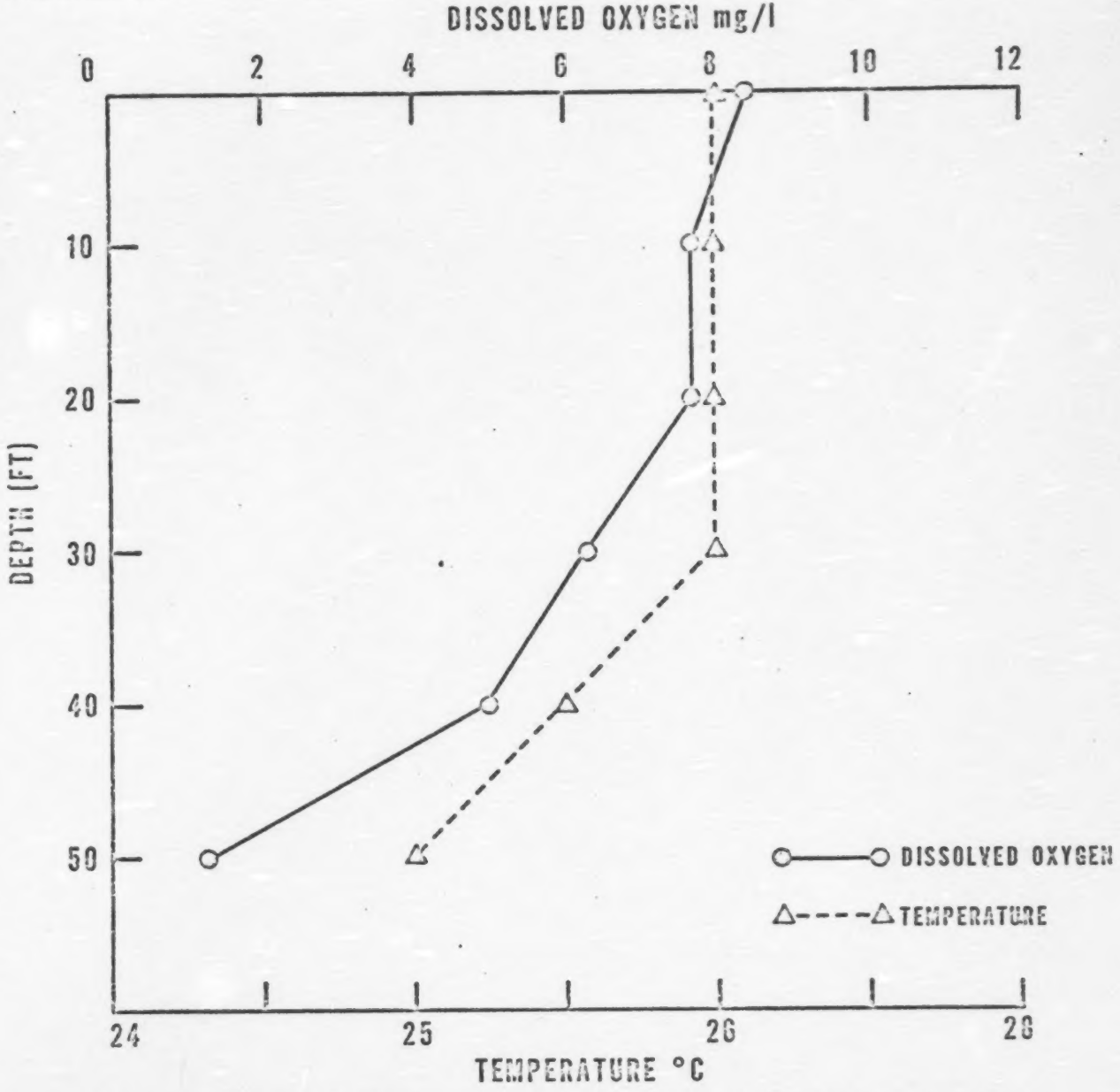

FIGURE 2. DISSOLVED OXYGEN AND TEMPERATURE PROFILES AT STATION 2, MILFORD RESERVOIR, KANSAS, AUGUST 11, 1980.

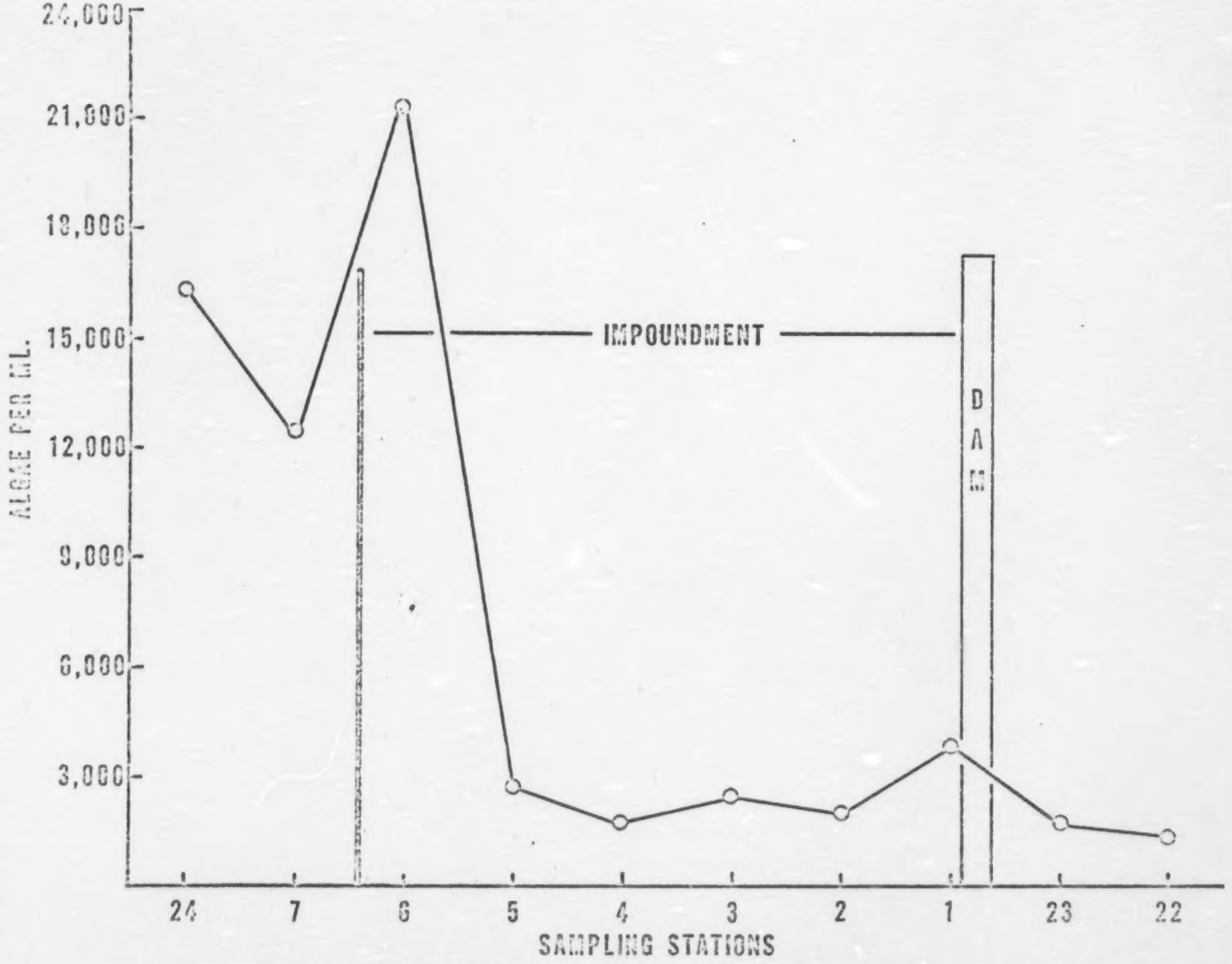

FIGURE 3. NUMBER OF ALGAE, MILFORD RESERVOIR, KANSAS, 1969.

5-6

surface waters of the main portion of the reservoir, inorganic nitrogen averaged 500 µg/l and the soluble phosphorus averaged 30 µg/l. The concentration of these nutrients did not vary greatly with depth. The concentration of soluble phosphorus decreased from 80 to 20 µg/l from the inlet to the outlet of the reservoir. This same magnitude of decrease was observed during the pre-impoundment survey in 1967 and during the subsequent post-impoundment survey in 1968. In 1969 the concentration of inorganic nitrogen decreased from 700 to 300 µg/l from the inlet to the outlet.

PHYTOPLANKTON

The Republican River upstream from Milford Reservoir (Stations 24 and 7) supported a large (11,600 per ml) population of phytoplankton (suspended algae). The population was comprised mainly of green algae (Scenedesmus and Schroederia) and flagellate algae (Chlamydomonas). Downstream at station 6, the size of the phytoplankton community increased to 21,500 per ml. This was the largest algal population observed at any of the stations. In the main portion of the reservoir (stations 1-5), the size of the algal population ranged from 400 to 3900 per ml. The greatest number of algae occurred at the downstream end of the impoundment (station 1) where the population was comprised primarily of Scenedesmus, Chlamydomonas, and Nitzschia. The algal population in the main downstream section of the reservoir (average of stations 1 and 2) was larger in 1969 than in 1968, increasing from 700 to 2600 per ml. This increase in numbers of algae did not cause any nuisance problems, yet were of sufficient abundance to support an increase in the numbers of bottom fish food animals.

Measurements of algal primary production (rate of inorganic carbon fixation by algae) at various depths throughout the reservoir showed that production was greatest in the downstream

section of the impoundment. Primary production was 540 mg C/m^2/ day at station 5 and increased to 3600 mg C/m^2/day at station 1. This high rate of algal productivity indicates that Milford Reservoir is the most productive impoundment studied by Division of Field Investigations, Cincinnati, biologists in the Missouri River Basin. A high rate of algal productivity commonly occurs in new reservoirs and usually lasts only the first five years. Because major nutrients are not limiting, Milford Reservoir should remain quite productive after the first five years.

Downstream from Milford Reservoir along the east bank of the river (station 23 rt.), the algal population numbered 1200 per ml which was about one-tenth of the population found upstream from the impoundment at station 27. However, an unknown source of nutrients entering from the west bank of the Republican River upstream from station 23 increases the algal population to 11,200 per ml (station 23 lf.).

BOTTOM ANIMALS

The community of bottom animals upstream from the reservoir (station 24) reflected excellent water quality. There the benthic fauna numbered 108 per sq. ft. and was comprised of 20 kinds of organisms, 10 of which are typically found in unpolluted environments. None of the organisms found upstream are normally associated with polluted conditions. As the result of the settling of silt in slack water areas (station 6), the density and diversity of bottom animals decreased in the upper reaches of the impoundment (Figure 4). The reservoir contained a benthic community comprised primarily of sludgeworms and phantom midges (Chaoborus), the latter of which are excellent fish food.

In 1968 only bottom animals indicative of a degraded environment were found downstream from the impoundment, whereas, in 1969, the bottom community was partially comprised of pollution-sensitive organisms such as mayflies and stoneflies. The improvement in the bottom community downstream from the impoundment probably resulted from the decrease in organic materials and the stabilization of the river flow and subsequently the stream bed. In 1969 the upstream and downstream benthic community was similar to that observed upstream and downstream from Harlan County Reservoir, Nebraska (Thomas and Lucas, 1970),

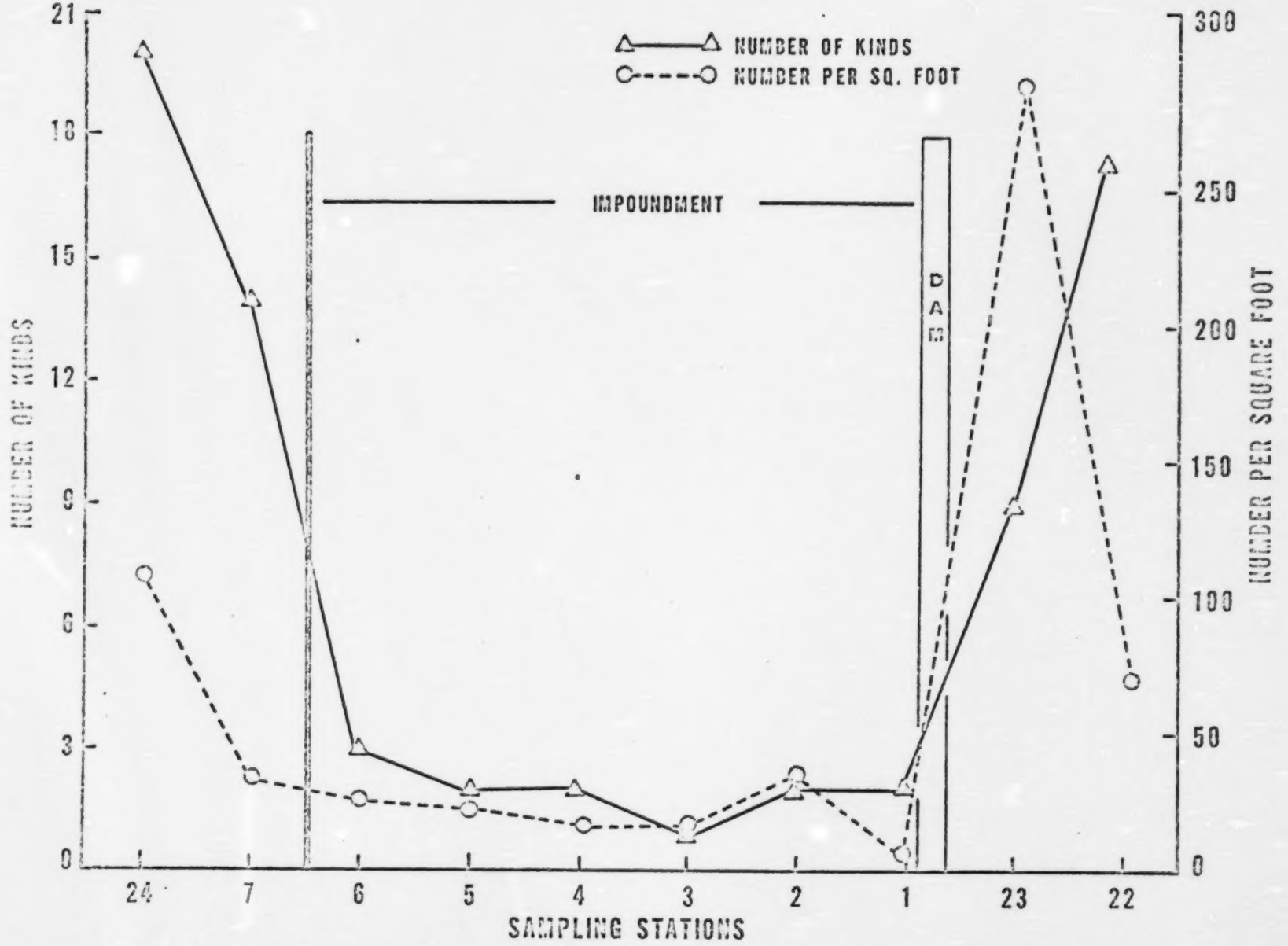

FIGURE 4. NUMBER OF KINDS AND NUMBER PER SQUARE FOOT OF BOTTOM ANIMALS, MILFORD RESERVOIR, 1969.

190 miles upstream from Milford Reservoir, indicating that excellent water quality existed throughout the Republican River and was not degraded by the impoundment of the river.

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Table 1

SUMMARY OF CHEMICAL AND BIOLOGICAL FINDINGS

MILFORD RESERVOIR

1967-1969

	Pre-Impoundment March 1967	Post-Impoundment Sept. 1967	Post-Impoundment August 1968	Post-Impoundment August 1969
Soluble Phosphorus, µg/l				
Inlet	130	-	190	80
Outlet	70	-	50	20
Total Phosphorus, µg/l				
Inlet	140	130	950	330
Outlet	70	70	80	60
Inorganic Nitrogen, µg/l				
Inlet	90*	300*	1600	700
Outlet	200*	200*	700	300
Phytoplankton, Surface, Outlet algae/ml	400	1900	700	2600
Gross Primary Production, Outlet				
mg $C/m^2/day$	-	-	370	2700
mg $C/m^3/day$	-	-	148	900
Bottom Organisms, Main Basin number/sq. ft.	0	8	6	33
Depth Euphotic Zone, feet	8.6	8.8	8.6	10.5
Bottom Organisms Upstream from Impoundment				
kinds	8	2	6	14
No./sq. ft.	68	4	6	35
Bottom Organisms Downstream from Impoundment				
kinds	7	4	8	9
No./sq. ft.	49	64	152	290

* NO_3-N only

Table 2. Milford Reservoir - Kansas

August 10-11, 1969

Algal and Chemical Data

	MR-24	MR-7 0'	MR-6 5'	MR-6 0'	MR-5 Rt 0'	MR-5 Rt 5'	MR-5 Rt 10'	MR-5 Rt 20'	MR-4 Lf 0'	MR-4 Lf 5'	MR-4 Ct 0'	MR-4 Ct 5'	MR-4 Ct 10'	MR-4 Ct 20'	MR-4 Ct 25'
Algae															
Green No/ml	7755	7755		9702	462	462	891	495	264	561	792	28	164	99	
ppm	16.3	20.2		30.3	1.0	0.8	1.9	2.0	0.1	4.1	0.3	0.1	-	0.1	
Blue Green No/ml	2211	1749		1749	429	198	33	429	198	198	198	165	66	33	
ppm	3.3	3.1		5.3	1.0	0.3	0.3	0.4	-	0.5	0.3	0.4	0.2	0.1	
Diatoms No/ml	462	198		5445	198	957	528	495	132	33	-	66	33	-	
ppm	1.1	0.1		38.3	0.2	1.5	0.3	0.3	0.4	-	-	-	-	-	
Flagellates No/ml	587	2475		4653	1815	1419	495	924	1122	528	1089	1848	561	264	
ppm	9.9	3.1		5.8	4.1	1.8	0.5	1.0	1.6	0.5	1.2	2.1	0.6	0.3	
Total No/ml	11015	12177		21549	2904	3036	1947	2343	1716	1320	2079	2104	924	396	
ppm	30.6	26.5		79.7	6.3	4.4	3.0	3.7	2.1	5.1	1.8	2.6	0.8	0.5	
Nutrients, mg/l															
NO_3-N	0.5	0.4	0.2	0.1	0.9	0.9	0.8	1.0	0.8	0.8	0.9	1.0	0.9	1.0	1.0
NH_3-N	0.30	0.3	0.1	0.03	0.22	0.05	0.10	0.10	0.09	0.12	0.27	0.10	0.06	0.10	0.16
Total Inorganic Nitrogen				0.1	1.1	0.9	0.9	1.1	0.9	0.9	1.2	1.1	1.0	1.1	1.2
Organic N	1.8	1.5	0.9	1.2	0.9	0.5	0.9	1.0	0.6	0.6	1.0	0.7	0.8	0.6	0.6
Soluble P	0.11	0.08	0.08	0.08	0.08	0.09	0.10	0.07	0.13	0.04	0.04	0.05	0.04	0.08	-
Total P	0.46	0.47	0.34	0.33	0.28	0.28	0.29	0.33	0.14	0.18	0.18	0.18	0.18	0.18	0.18

No Sample

Table 2 (Cont.) Milford Reservoir - Kansas

August 10-11, 1969

Algal and Chemical Data

	MR-3 Ct 0'	MR-3 Ct 5'	MR-3 Ct 10'	MR-3 Ct 20'	MR-3 Ct 40'	MR-3 Rt 0'	MR-3 Rt 5'	MR-2 Lf 0'	MR-2 Lf 5'	MR-2 Ct 0'	MR-2 Ct 5'	MR-2 Ct 10'	MR-2 Ct 20'	MR-2 Rt 0'	MR-2 Rt 5'
Algae															
Green No/ml	660	363	165	396	297	198	99	627	297	495	231	132	66	594	825
ppm	1.0	0.2	-	0.4	0.6	-	0.1	0.7	0.7	-	0.4	-	-	0.6	0.7
Blue Green No/ml	330	363	165	396	165	330	33	264	429	462	363	231	33	164	594
ppm	0.3	0.5	0.4	0.8	0.4	0.4	-	0.5	0.7	0.7	0.7	0.3	0.1	0.5	0.9
Diatoms No/ml	-	99	-	99	33	132	132	198	33	66	33	66	99	99	-
ppm	-	0.1	-	0.1	-	-	0.1	0.1	-	0.1	-	-	0.1	0.1	-
Flagellates No/ml	1584	1617	825	594	231	2178	1188	825	4422	858	2013	858	733	1089	2475
ppm	1.9	2.1	0.9	0.7	0.2	3.8	3.0	0.9	5.0	1.1	2.2	0.9	0.6	1.2	2.7
Total No/ml	[illegible]	[illegible]	1155	1485	726	2838	1452	1914	5181	1881	2640	1221	931	1946	3894
ppm	3.1	3.1	1.3	2.0	1.2	4.2	3.2	2.2	6.4	2.0	3.3	1.2	0.8	2.4	4.3
Nutrients, mg/l															
NO_3-N	0.5	No sample	0.6	0.5	1.1	0.9	0.9	0.6	0.4	0.5	0.5	0.6	0.6	0.5	0.5
NH_3-N	0.01		0.07	0.05	0.03	0.09	0.10	< 0.01	0.09	0.07	0.04	0.05	0.04	0.08	0.14
Total Inorganic Nitrogen	0.5		0.7	0.5	1.1	1.0	1.0	0.6	0.5	0.6	0.6	0.6	0.6	0.6	0.6
Organic N	0.7		0.7	0.5	0.7	0.7	0.7	0.5	0.9	0.7	0.6	0.6	0.6	0.9	0.7
Soluble P	0.05		0.05	0.04	0.04	0.09	0.05	0.025	0.06	0.04	0.02	0.04	0.05	0.05	0.02
Total P	0.13		0.11	0.09	0.10	0.16	0.20	0.07	0.08	0.08	0.11	0.07	0.07	0.08	0.09

Table 2 (Cont.) Milford Reservoir - Kansas

August 10-11, 1969

Algal and Chemical Data

	MR-1 Lf 0'	MR-1 Lf 5'	MR-1 Ct 0'	MR-1 Ct 5'	MR-1 Ct 10'	MR-1 Ct 20'	MR-1 Ct 30'	MR-1 Ct 40'	MR-1 Ct 50'	MR-1 Rt 0'	MR-1 Rt 5'	MR-25 Lf	MR-25 Ct	MR-25 Rt	MR-22
Algae															
Green No/ml	792	363	429	1056	330	264	272	297	170	1257	396	2574	627	198	594
ppm	0.7	0.4	0.3	1.3	0.3	0.2	0.2	0.4	0.1	1.6	0.4	2.1	1.5	0.1	0.8
Blue Green No/ml	429	363	462	396	198	198	85	99	102	726	264	825	429	231	462
ppm	0.5	0.7	0.8	0.4	0.4	0.3	0.2	0.3	0.3	1.3	0.4	1.7	0.6	0.4	0.9
Diatoms No/ml	99	66	-	66	-	264	255	33	221	33	-	1386	132	132	33
ppm	0.1	-	-	0.1	-	0.2	0.2	-	0.2	-	-	0.9	0.1	0.1	-
Flagellates No/ml	2607	2046	1683	1947	858	792	238	627	85	2178	419	6435	825	660	396
ppm	3.1	2.7	1.9	2.1	0.8	0.4	0.1	0.5	-	2.6	0.2	7.9	0.8	0.4	0.4
Total No/ml	3927	2838	2574	3465	1386	1518	850	1056	578	4194	1079	11220	2013	1221	1485
ppm	4.4	3.8	3.0	3.9	1.5	1.1	0.7	1.2	0.6	5.5	1.0	12.6	3.0	1.0	2.1
Nutrients, mg/l															
NO_3-N	0.3	0.4	0.3	0.4	0.4	0.5	0.8	0.2	0.4	0.4	0.3	< 0.1		0.4	0.5
NH_3-N	0.14	0.08	< 0.01	0.10	0.08	0.04	0.01	0.15	0.09	< 0.01	0.07	0.20	No Sample	0.06	0.14
Total Inorganic Nitrogen	0.4	0.5	0.3	0.5	0.5	0.5	0.8	0.2	0.5	0.4	0.4				
Organic N	0.9	0.6	0.8	0.7	0.6	0.5	0.7	0.6	0.5	0.9	0.6	0.8		0.6	0.6
Soluble P	0.02	0.03	0.016	0.03	0.03	0.03	0.04	0.03	0.04	0.05	0.02	0.04		0.03	0.09
Total P	0.08	0.07	0.08	0.06	0.06	0.06	0.08	0.08	0.09	0.09	0.05	0.20		0.08	0.18

Table 5. Milford Reservoir - Kansas
August 10-11, 1969
Bottom Animal Data
(Number per Sq. Ft.)

	MR-24	MR-7	MR-6	MR-5 Lf. Out of Channel	MR-5 Rt. Silt	MR-4 Rt.	MR-4 Ct.	MR-4 Lf.	MR-3 Ct.	MR-3 Lf.	MR-3 Rt.	MR-2 Rt.	MR-2 Lf.	MR-2 Ct.	MC-1 Lf.	MC-1 Rt.	MR-23 Left Channel	MR-22 Republican River
Mayflies																		
Isonychia	Q	Q	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pentagenia	34	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenonema	1	Q	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Q
Caenis	4	5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Heptagenia	Q	Q	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Q
Baetis	3	Q	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
Trichorythodes	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Q
Caddisflies																		
Cheumatopsyche	26	Q	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	8
Hydropsyche	3	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	10
Agraylea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
Stoneflies																		
Acroneuria	Q	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Midges																		
Pelopia	2	-	-	1	7	-	-	10	-	-	-	-	-	-	-	-	-	-
Polypedilum	22	Q	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11
Pseudochironomus	Q	Q	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tanytarsus	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	42	13
Chironomus	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	196	2
Spaniotoma	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	34	3
Cryptochironomus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11
Pentaneura	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Procladius	-	-	-	-	-	-	-	-	-	-	-	2	-	2	-	2	-	-
Dolichopodidae	-	Q	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chaoborus	-	-	2	-	19	-	12	15	-	15	2	27	17	25	3	3	-	-
Blackflies																		
Simulium	Q	Q	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Prosimulium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Q	-
Limpets																		
Ferrissia	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Q
Flatworms																		
Planaria	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Q
Damselflies																		
Amphiagrion	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Q
Dragonflies																		
Gomphus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Q
Snails																		
Physa	Q	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Q	Q
Sludgeworms	-	15	22	-	20	-	-	17	2	5	25	-	22	7	2	-	-	-
Copepods																		
Cyclops	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
Total No. Kinds	20	14	5	1	2	0	1	3	1	2	2	2	2	3	2	3	9	17
Total No./Sq. Ft.	108	35	26	1	46	0	12	42	2	20	27	29	39	34	5	7	290	70

Q - Collected in qualitative samples only.